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Finite difference time domain modeling of light matter interaction in light-propelled microtools

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Direct laser writing and other recent fabrication techniques offer a wide variety in the design of microdevices. Hence, modeling such devices requires analysis methods capable of handling arbitrary geometries. Recently, we have demonstrated the potential of microtools, optically actuated microstructures with functionalities geared towards biophotonics applications. Compared to dynamic beam shaping alone, microtools allow more complex interactions between the shaped light and the biological samples at the receiving end. For example, strongly focused light coming from a tapered tip of a microtool may trigger highly localized non linear processes in the surface of a cell. Since these functionalities are strongly dependent on design, it is important to use models that can handle complexities and take in little simplifying assumptions about the system. Hence, we use the finite difference time domain (FDTD) method which is a direct discretization of the fundamental Maxwell's equations applicable to many optical systems. Using the FDTD, we investigate light guiding through microstructures as well as the field enhancement as light comes out of our tapered wave guide designs. Such calculations save time as it helps optimize the structures prior to fabrication and experiments. In addition to field distributions, optical forces can also be obtained using the Maxwell stress tensor formulation. By calculating the forces on bent waveguides subjected to tailored static light distributions, we demonstrate novel methods of optical micromanipulation which primarily result from the particle's geometry as opposed to the directly moving the light distributions as in conventional trapping.

KEYWORDS

Microfabrication, Optical trapping, Finite difference time domain, Maxwell stress tensor

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